The Future of the Grid

Evolving to Meet America's Needs

Western Region Workshop Summary

December 11, 2013

Redmond, Washington

GRIDWISE ALLIANCE

DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

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Table of Contents

Introduction 1

Workshop Approach 3

Key Findings 4

Summary of Messages to Policy Makers 6

Summary of Necessary Actions 7

Opening Remarks 8

Vision: Capabilities and Functions of the Future Grid 9

Scenario 1: Balancing Supply and Demand as Grid Complexity Grows 11

Scenario 2: Involving Customers and Their Loads in Grid Operations 14

Scenario 3. Higher Local Reliability through Multi-Customer Microgrids 20

Scenario 4: Transitioning Central Generation to Clean Energy Sources—Large Wind, Large Solar, and Large Gas 24

Scenario 5: Planning for Empowered Customers 28

Conclusion and Next Steps 33

Appendix A. Setting the Stage: Factors to Consider 34

Appendix B. Workshop Agenda 36

Appendix C. Attendees 39

Introduction

The U.S. electricity system is undergoing a major transformation that will continue for the next 25–30 years. The rapid evolution of electricity supply and end use will have major implications for reliability, transmission and distribution, customer engagement, security, and integration.

Regardless of the ultimate generation mix or the policies in place, the electric grid will play a critical role in future electricity infrastructure. In fact, it is an essential, enabling platform that supports America's economic activity, similar to the cellular network, which enabled the world of smartphones and mobile applications.

Thoughtful debate and planning are needed today in order to address tomorrow's challenges and seize on tomorrow's opportunities. With this in mind, the GridWise Alliance (GWA) and the U.S. Department of Energy's (DOE's) Office of Electricity Delivery and Energy Reliability (OE) are hosting a series of workshops across the country (four regional workshops followed by an executive summit) to develop an industry-driven vision of the nation's future electricity grid. During the regional workshops, thought leaders from all stakeholder groups (utilities, regulators, state government officials, renewable energy providers, suppliers, and industry innovators) are coming together to define the needed capabilities, the changing role of grid operators, the new technologies and financial models required to drive investment, and the policy and regulatory barriers to realizing the vision.

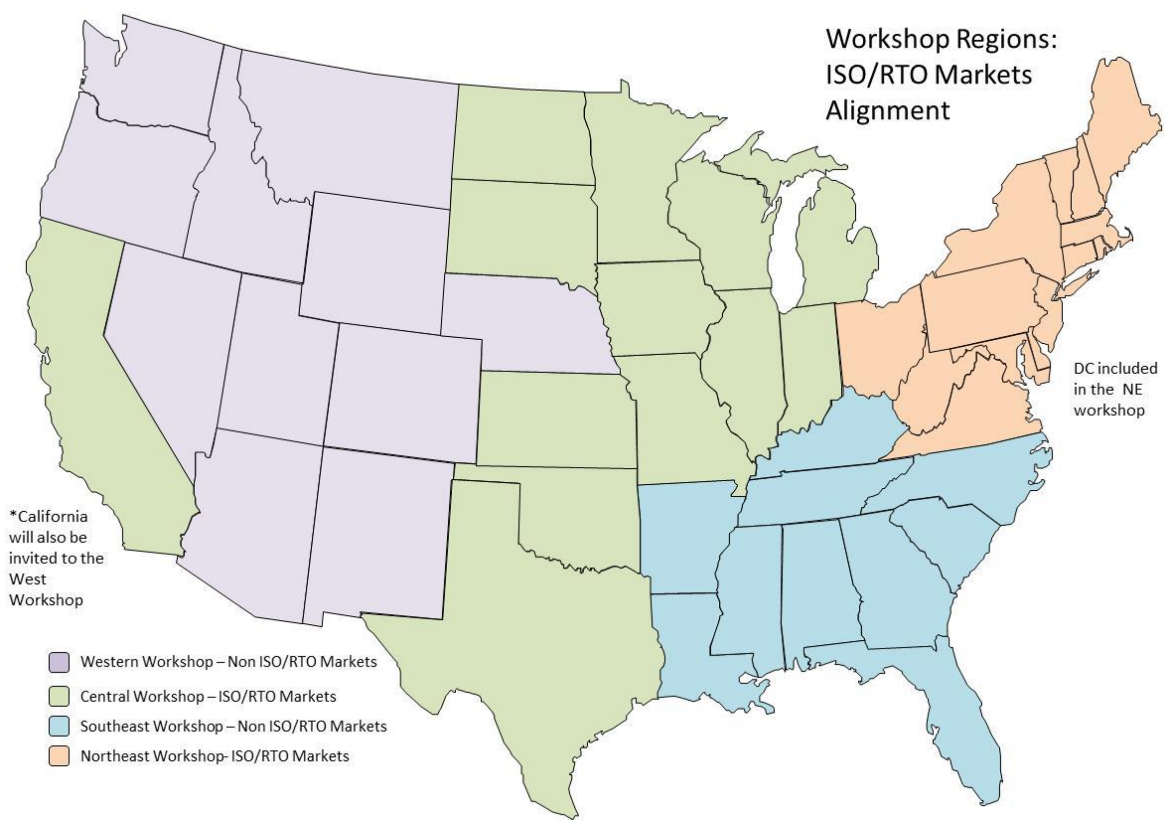

Figure 1. Workshop region designations

The regional designations for the workshops are identified in Figure 1 and align along Independent System Operator (ISO)/Regional Transmission Organization (RTO) markets. California, due to its unique characteristics, will be included in both the Western and Central Region workshops.[1]

Following the regional workshops, an executive summit will take place in Washington, DC, to review, synthesize, and validate the findings and themes that emerge from the regional discussions. The results from this effort will inform larger DOE efforts to help guide research and development agendas and serve to educate all stakeholders—including state and federal policy makers and regulators—on the issues that must be addressed to ensure that the future grid is affordable, reliable, and resilient to support economic prosperity and energy security.

[1] California is geographically aligned with the Western region and shares many renewable energy and environmental drivers common to other Western region states. California is also aligned with the Central region in terms of its use of an ISO to regulate its wholesale market and the nature of the utility-customer relationship.

Workshop Approach

The structure of each of the four regional workshops is the same. The day begins with a visioning exercise in which participants are asked to forget the current legacy system and think about the type of system they would design today if starting anew. Participants are then split into breakout groups, each of which is given a different scenario to discuss considering a future state of the grid in 2030. The breakout groups then participate in facilitated discussions to answer questions about grid capabilities, grid operations, business models and investments, and regulatory and policy barriers and opportunities in the context of their assigned scenario, while keeping in mind the vision for the future grid. The workshops feature open and frank discussions by employing Chatham House Rules, which permit participants to speak freely without the fear of attribution. The complete workshop agenda for the Western Region workshop can be found in Appendix B.

Although the scenarios are anchored in key factors affecting the grid, they do not represent an exhaustive examination of what is possible in 2030. Instead, they highlight the most likely scenarios and key areas that are plausible and facing industry today. The scenarios serve to guide the discussion of "2030 grid operations" from important and somewhat different perspectives. Participants are asked not to debate whether the scenario will occur, but to consider what new technologies, capabilities, or policies would be needed or what limitations might exist to transform today's system into the future vision.

The same five scenarios are discussed at each workshop:

- Balancing Supply and Demand as Grid Complexity Grows
- Involving Customers and Their Loads in Grid Operations
- Higher Local Reliability through Multi-Customer Microgrids
- Transitioning Central Generation to Clean Energy Sources—Large Wind, Large Solar, and Large Gas
- Planning for Empowered Customers

Regional differences will likely emerge from the different workshops as these scenarios are discussed throughout the country. These differences are included in each region's stakeholder-driven vision and will be captured as part of the broader national-level vision.

The Western Region workshop—the first in this series—took place in Redmond, Washington, on December 11, 2013. Fifty-seven participants attended the workshop; Figure 2 shows the breakdown by stakeholder group. The complete list of attendees is provided in Appendix C.

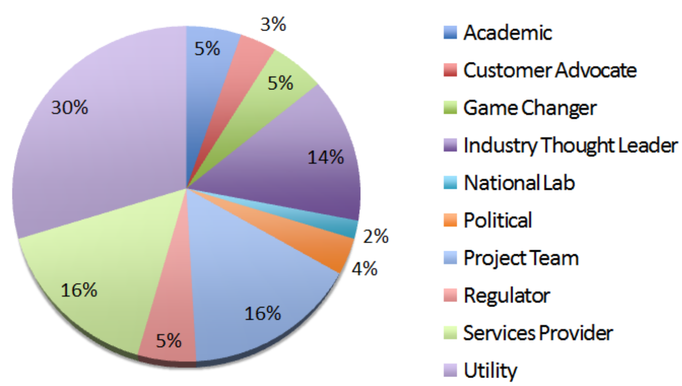

Figure 2. Breakdown of Western Region workshop participants

Participants were given an extensive set of pre-read materials before the workshop describing the scenarios and highlighting factors to consider. These materials set the stage for the workshop and provided context for the discussions. Appendix A contains a summary of the key factors participants were asked to consider.

Key Findings

Participants at the Western Region workshop noted the value of the frankness and openness of the discussions as well as the diverse stakeholder representation. Participants appreciated the opportunity to gather with peers to talk about these important topics. Throughout the discussions, several key themes emerged:

Operations

- Although overall end-user demand may increase, generators and grid operators in this region are expected to see demand hold steady or decline, due to increased distributed generation and energy efficiency measures.
- Customers will expect choice and control over their electricity usage. Clear and direct pricing signals will be critical.
- The line between transmission and distribution is blurring. Operations for distribution will become more similar to transmission as the balancing of generation and load begins to reach down to the device level. This blurring of transmission and distribution will create jurisdictional regulatory challenges.
- Grid operations will be increasingly complex and will require greater situational awareness. Visibility will be needed across the entire grid—down to the device level.
- New technical standards for end-use devices will be needed.
- There will be workforce challenges. Employees will need a combination of operational technology (OT) and information technology (IT) skills. It will be necessary for employees to know how all of the pieces fit together and to be able to deal with increasing grid complexity.
- There are varying views on whether more or fewer balancing authorities will be needed. Some participants believe balancing authorities' roles will be more focused and extend down to the distribution level, while others think balancing authorities will extend to wider areas.

Business Models and Pricing

- New pricing models for the grid and grid operations are needed to facilitate the shift from a commodity delivery model to a services model. These pricing models need to take into consideration the "value add" services and address the increasing risk of stranded costs.
- Development of new pricing models should also consider the implications of capital costs versus operations and maintenance (O&M) costs as they relate to future investment in and operations of the grid. Considerations should include how the future grid owner/operator will make money, and whether profits should be based on capital investments or based on more efficient system operations and services provided.

Policy

- Utilities have been tasked with implementing certain public policies through their rate structures. As a result, current rate structures have socialized certain costs and provided subsidies for some customer groups. Clear and transparent public policies will need to be established regarding whether electricity is a basic right. Policy makers will need to decide this issue in order to provide clarity and certainty about the goals for electricity delivery. Clarity on this issue will also help define basic infrastructure needs. A clear path also needs to be established on whether utilities need to be compensated in a way so that basic infrastructure is in place and maintained, allowing utilities to serve as a provider of last resort as customers elect to go off grid.

- Uncertainty around policy and regulations could hamper future investments and may have unintended consequences. Greater direction will help utilities determine the business changes and technology advancements that are needed to survive.
- Constructive conversations between regulators and other industry stakeholders will help to advance the understanding about the realities and consequences of various technologies, pricing structures, and infrastructure investments.

Summary of Messages to Policy Makers

During the breakout sessions, participants identified the most important messages for policy makers to consider when developing future policies:

- The utility structure will change, but new business models have not yet been determined. New business models are needed that encourage appropriate investment in infrastructure and fund ongoing grid O&M. Financial viability is needed to (1) maintain the resiliency and reliability Americans expect, (2) integrate distributed energy resources, and (3) meet the changing needs of customers.
- Rate reform is required that is flexible, encourages distribution system investment and development, and enables local services.
- Policies and regulations must accommodate and promote innovation in grid modernization. They must be nimble in order to enable the integration of new technologies and emerging business models.
- Policies and tools are needed that enable an orderly transition to avoid a "death spiral" for utilities and to ensure that lower-income customers are not left behind.
- Policies should address environmental externalities in a cost-effective manner.
- Regulatory reform is needed to encourage and support balancing authority capability, enable infrastructure development, and lay the foundation for commerce at the local level. Regulations should balance the "common good" and the "beneficiaries pay" philosophies.
- Incentive structures, which can be useful in engaging customers, will be needed due to the rapid rate of change in the industry. These incentives should be adaptive so that customers do not base their investment decisions on the assumption that the incentives will continue long term, and so that the incentives can be modified appropriately as conditions change.
- Coordination is greatly needed among the numerous agencies involved in energy regulation so processes and approvals can be streamlined.
- Customers are becoming more demanding and have higher expectations. Technology must evolve to meet these needs and will play a more important role in the future grid. Resiliency and reliability must be maintained.
- Integration of customer-owned distributed generation will continue.

Summary of Necessary Actions

During the breakout sessions, participants recommended actions that should be taken in order to facilitate the evolution of a cost-effective, reliable, and resilient grid of the future:

Overarching

- A multi-stakeholder, multi-perspective task force or another similar process should be established to look closely at the utility business models. The process should explore how utilities make money, how ratepayers are protected, and how social objectives are achieved.
- An industry-driven vision for the enabling infrastructure must be developed.
- Investments must be made in standards and technology development to support the grid.

Operations

- New transmission must be enabled.
- The system needs to be more flexible and responsive to wide fluctuations and ramping, especially the fall off of renewable energy resources.
- A workforce must be cultivated that possesses IT and OT skills and can support the grid's new functions. Cultivation should involve developing a strategy for workforce investment and workforce skills assessment, as well as workforce training.

Business Models and Pricing

- The rate structure needs to be redesigned to transition from a volumetric-based structure to a fee-based structure. The new rate design will need to accommodate customers' desires, as well as include considerations for socializing some costs to protect low-income customers. Services that customers value will need to be incorporated. Pricing must be transparent for all services that form a part of the resilient grid. Rate design or pricing models should consider the following: (1) the question of energy equality—whether access to electricity is a basic right; (2) the implications of large numbers of customers disconnecting from the grid; (3) the value to customers of new services and programs; and (4) the total cost of electricity, including externalities.
- Utilities must be able to monetize multiple value streams from their infrastructure by providing additional services to consumers and finding ways to effectively engage them.
- Investments must be made in developing new standards and technology (e.g., interconnections, contracts, software, and hardware) to support the new grid.

Policy

- Federal and state jurisdictions will need to be refined and clarified.
- Better coordination between federal and state regulatory agencies is needed to streamline and speed up processes and approvals.
- Enforceable carbon pricing should be considered.

Opening Remarks

Hon. Philip Jones, Commissioner of the Washington Utilities and Transportation Commission (Washington UTC) and former president of the National Association of Regulatory Utility Commissioners (NARUC), shared some opening remarks.

Commissioner Jones stated that this is an unprecedented time in the electric power industry, and that it is important for state regulators to engage proactively. He cited technology (specifically the smart grid and intelligence in the grid), environmental regulation, and Section 111d of the Clean Air Act as key factors in driving the resource mix. He also stated that silos related to water, natural gas, and shale gas are converging, with shale gas pushing out wind, solar, and nuclear power. In addition, he remarked that secular stagnation, in place since 2008, might be the new normal, and that state commissions still have statutory responsibilities to ensure affordable, reliable power, as well as reasonable rates.

Commissioner Jones then detailed NARUC's recent activities. He reported that NARUC has been very involved with smart grid efforts, cybersecurity efforts, and the Smart Grid Interoperability Panel. He also noted that NARUC has been following Bonneville Power Administration's Sychrophaser Project, the smart grid demonstration project in Washington State, and the Eastern Interconnection States' Planning Council's efforts with transmission planning.

He discussed new interconnection rules, noting that distributed generation is an important topic. He mentioned that Washington UTC has recently revised interconnection rules for distributed generation and is working to develop rules and policy statements for governance. In addition, he described NARUC's recent report on resilience as a conversation starter on the definition of resilience, noting that the concept means different things to different people.

Commissioner Jones discussed the political realities of the Northwest. He noted that there are 38 balancing authorities and only 43% of the load is delivered by investor-owned entities (with the balance delivered by publics, muni, and co-ops), meaning that Washington UTC has authority over slightly less than half of the delivered load.

Vision: Capabilities and Functions of the Future Grid

Becky Harrison introduced the large group Visioning Exercise, asking participants to consider the capabilities and functions of the future grid starting with a "blank sheet of paper." This brief exercise was not intended to produce a consensus; instead, it provided participants with an opportunity to brainstorm in order to expand their thinking and envision the grid without the constraints imposed by the legacy infrastructure and business models. The exercise informed and stimulated conversation in the breakout group discussions that followed.

Elements of the Future Grid
Brainstorming Ideas from Workshop Participants

- Market for distributed generation exists: active balancing of generation and load on a local basis. Increased ability to island.
- A "federation" of microgrids with an established set of rules. The grid operator provides rule setting and plays a U.S. Securities and Exchange Commission-type role. The central grid supports the federation.
  - Cost to consumers to go off grid is low/cost-effective for this "federation" to work.
- Customers receive and respond to price signals. A truly integrated price signal between generation and the grid. Balancing authorities make up the difference.
- Determination of the core prices is key. Externalities (carbon prices, incentives for particular generation types) must be baked in before the vision can be defined. Expiration of tax credits and incentives.
- Self-reconfiguring/self-healing grids.
- Ability to forecast solar and wind more reliably on a local level. This will help combat intermittency.
- More homes moving toward becoming net-zero or completely self-sustaining, or being completely disconnected from the grid.
  - Resiliency is a key factor for the move.
- Open-access nationwide network model. Central markets have accurate, real-time models—need to extend this model down to customers' devices.
  - Energy use tied to generation. Markets coupled with supply and demand.
  - Smart charging for electric vehicles could be part of this model.
  - Standby generation is more widespread.
  - Just one grid—not separate transmission and distribution grids. The boundaries would not stop at state lines.
- Aggregation of all customer loads to help with balancing. This will reduce customer costs.
  - Institutional and government structures that align with the new grid model to provide flexibility, efficiency in decision making, and alignment among the current network of institutions involved in the grid today.
- Remote customers will probably not be served by utilities because of the expense, so co-ops will likely be needed.
  - Total open transparency will help this issue. There are wires to all of the homes already.
- Goals for the future grid: Every customer served, as cleanly, cheaply, and reliably as possible.
- The perfect grid has solved the "vicious cycle" noted in the Edison Electric Institute paper.
- The price signal is central. Transactive grid—needs to accomplish smart charging for electric vehicles, as well as any and all other smart devices.
- Who will invest in infrastructure—a new model based on value of service, not infrastructure

deployed.
- Grid parity for small projects (generation, microgrids) is very expensive.
- In the open model, customers are still ratepayers of some kind.

Other Thoughts Presented by Participants

- Distributed generation is massively subsidized, and it is unclear if the market will truly support it and whether the solution will be cheaper than the status quo.
- Some policies toward distributed generation are not furthering the goals of serving every customer as cleanly, cheaply, and reliably as possible.
- It is not clear if capital could be attracted with a fresh start. Long-term certainty is needed to attract the 30-year investments that are necessary to get things off the ground.
- Policies will drive the final outcome of the grid infrastructure and market.
- To ensure that all customers are served, it is necessary to have a totally open and transparent system. With the open model, it is possible to empower customers to have basic electricity under all possible conditions and keep the average price down when heat waves, etc. occur. Institutional barriers stop the innovation required to make this happen.

Scenario 1: Balancing Supply and Demand as Grid Complexity Grows

Description of the Scenario

This scenario is characterized by:

- On the customer side: increased distributed generation and storage at the residential level as well as larger distribution-size renewables; for example, microgrids, community renewable projects, smarter home energy management systems, smart appliances, and electric vehicle (EV) charging.
- On the transmission side: increasing penetration of non-dispatchable generation sources ("large wind"), more utility-scale renewables, and utility-scale energy storage.
- Increased use of customer devices or generation to balance the system or provide ancillary services.
- Increased dependence on smaller generation versus large baseload generation or peaking plants to manage the system.

Together, these characteristics suggest a need for:

- Managing two-way power flows for the distribution grid, not only the transmission grid.
- Enhanced balancing capabilities to balance more complex supply and demand options. Greater dependence on "edge-of-the-grid devices."
- Greater interaction between the distribution and transmission grids and grid operators to optimize the balancing of supply and demand.
- Enhanced weather forecasting methods.

Path Forward: Articulating the Vision

The following summarizes the Scenario 1 breakout session discussions. This content was generated entirely by participants and reflects their vision for the future electricity grid under the Scenario 1 assumptions.

Description of the Group's Future Grid, Based on the Scenario

- **Greater reliance on automation. The grid will be enabled with automation down to the consumer level.** Automation will provide the ability to manage load similar to how generation is managed, in close to real time, with enabled control of aggregated loads and based on the needs of the grid.
- **The grid will provide clear and direct market-driven price signals to optimize its performance.** Education is needed to inform customers on why this would be important to them and to empower them to take control of their energy use. Different levels of customer services are needed for customers with unique needs (e.g., the articulation of unique service offerings for large consumers to access ancillary services markets or various rate structures). Businesses and services will be created and offered to customers with the intention of leveraging dynamic price signals and optimization.
- **The grid will provide visibility to and control of both supply and demand for operators.**

- **The grid will be flexible to accommodate for the evolution in the utility business model and the integration of new technologies.**

New Capabilities and Functions

- **The grid will have two-way data flow functionality.** New testing requirements and certification processes are needed for system interoperability and interchangeability. Funding is needed for activities related to standards work and the implementation of emerging standards. Holistic sharing of data, across industries, will be crucial to optimize performance. Multiple sources of information, not just electric utility information, will impact the grid and its performance. Devices at every level will interface with the grid, down to the sensor-to-sensor level. Data will be pushed from the grid to devices and from devices to the grid. New grid technologies must be dynamic in nature and have the capability to adapt and update to new functionality and performance standards. There will be a faster rate of replacement with these technologies.
- **The grid will be optimized through operational automation.** The importance of operational technology as part of a solution to address challenges will become more evident.
- **The grid will be resilient to both cyber and physical threats.**

Differences for the Operations Centers

Transmission:

- **The transmission grid will coordinate with the distribution system.** Better coordination will be needed between transmission and distribution operators to increase efficiencies.
- **The transmission grid will have greater visibility to the edge of the grid.** More transparent availability of data is needed to optimize operational performance. Operational requirements must be extended down and through the system in aggregate to fully leverage capabilities.
- **The transmission grid will rely on operational automation.**
- **The transmission grid will be secure.** Security and privacy concerns must be managed across the system. All systems must be cyber-hardened. Privacy/security barriers need to be addressed at the regulatory level locally, regionally, and nationally.

Distribution:

- **The distribution grid will look more like the transmission system.** Input is needed from customers regarding generation and load. Full visibility is needed into the distribution system. This visibility will allow operators to fully leverage the capabilities of the system, as needed, to effectively manage distribution operations.
- **The distribution grid will coordinate with the transmission system and customers.** Control of distributed generation assets must be reconciled through operating utilities. The rationale behind deeper data sharing and access to information needs to be effectively messaged to consumers to establish buy-in and realize performance improvement.
- **There will be reliance on automation to control the grid as well as balance generation and load at the customer level.**

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

- **Policies and regulations must accommodate and promote innovation in grid modernization.** Policies and regulations are needed that create flexibility and allow for innovation without being prescriptive. The historical utility approach of providing energy to consumers as needed should be modified to reflect emerging new customer classes that are producing power and more directly interacting with the grid. This transition will be accelerated with the adoption of smarter policies and regulations.
- **The utility structure will change, but the new model has not yet been determined**. The structure of utilities will have to change because of declining demand and more customer generation, but it is unclear what that structure will be. In 20 years, utilities might serve as a type of insurance by providing backup services. This arrangement might be inexpensive for residential customers but very expensive for industrial customers.
- **Adaptive incentive structures will be needed due to the rapid rate of change.** Incentives are useful in engaging customers and securing customer involvement. Superfluous subsidies and incentives should be avoided; subsidies and incentives should be used in a sustainable way or at least be adaptive so that customers do not assume that there will always be incentives. Change is occurring too quickly for the old model to work.
- **Policies and regulations must be nimble to enable the integration of new technologies and emerging business models.** New systems and technologies will have lower life expectancies by design. Regulations and policies will need to recognize and accommodate these shorter life spans. Emerging policies and regulations will address numerous emerging issues that impact grid operations, including, but not limited to, the following:
  - Resources with low wholesale rates must still be compensated.
  - Markets need to be created to leverage new technologies and the services they enable within current market constructs that include legacy technologies.
  - How revenue from EV charging networks will be managed has to be determined.
  - Customers must be engaged without being overly subsidized, and subsidies must be sustainable and adaptive.
  - Incentives must facilitate the deployment of smart devices into homes.
  - The disconnect for consumers between wholesale and resale prices must be reconciled.
  - Financial models are challenged, and effective policy will address these challenges.
  - Technological assumptions (e.g., ubiquitous storage) cannot be made, and policies and regulations should open doors rather than close them.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Clarify federal/state jurisdictions.**
- **Consider enforceable carbon pricing.**
- **Train the workforce of the future (IT, OT, power engineering overlap).** IT professionals will be paramount. The merging of OT and IT will also be critical. A workforce with these combined skills will be in high demand. This domain area needs to be further developed in universities or through a forum for professionals.

Scenario 2: Involving Customers and Their Loads in Grid Operations

Description of the Scenario

This scenario is characterized by:

- Retail availability of smart devices and customer expectations that devices will "plug and play" with grid operations.
- Greater customer control over, and ability to react to, the price of energy. A greater number of available service options.
- Increased availability and prevalence of smart devices, along with EVs that can respond to signals from the grid operator. Devices are capable of two-way communication with the grid.
- A significant increase in local (edge-of-grid) clean generation (such as rooftop solar), electrified transportation, and storage to meet individual customer (residential, commercial, and industrial) needs and expectations. Ancillary services being met through the control of these devices. An imbalance between reduced/falling overall demand and higher peak demand.

Together, these characteristics suggest a need for:

- The ability to incorporate complex economics with complex physical integration.
- An architecture and design that can optimize the loads and their response in a way that maximizes efficiency and minimizes costs.
- Ways to synchronize the operation of potentially millions of devices at the edge of the grid.
- Ways for the grid to adapt when edge-of-grid devices are scaled from hundreds to tens of thousands. Customers are unaware how their own choices impact larger grid operations; when these individual decisions are scaled to hundreds or thousands of devices, the impact to grid operations will be tremendous.
- A "transactive energy" concept, representing the complex interaction between physics and economics at the edge of the grid. The Western region in particular is already developing this concept and experimenting with applying it in practice.

Path Forward: Articulating the Vision

The following summarizes the Scenario 2 breakout session discussions. This content was generated entirely by participants and reflects their vision for the future electricity grid under the Scenario 2 assumptions.

Description of the Group's Future Grid, Based on the Scenario

The group discussed a range of possible outcomes or scenarios that could unfold based on Scenario 2 assumptions. Several key questions arose during the discussion (see text box on page 15). The group arrived at two possible visions for the future grid:

- **Vision A:** Cost-efficient microgrids and distributed generation will displace grid-supplied electricity for most consumers, allowing for individual choice. Customers will choose to opt out of the grid and have their own generation and possibly backup storage. The remaining grid will be mostly transmission with a little bit of distribution to support industry. There will not be any wires to individual customers.

- **Vision B:** The electricity delivery system will be enhanced to provide added services and value. Customers will choose to remain connected to the grid. Society will determine that maintenance of the overall electric grid is important. Rates will be socialized (with a tax or fee) to maintain the health of the grid.

The group's discussion of Vision A is summarized below. The group's discussion of Vision B begins on page 17.

Questions that led to the discussion of the visions:

- As a U.S. citizen, do you have a right to electricity?
- Should the customer have the choice to go off-grid, which could hurt others in the system due to the current socialization of rates?
- Should some subsidize the rates of others to maintain the health of the entire system?
- Should utilities become providers of base-level service?

Vision A: ***A diminished role for the utility ("death spiral")***
How the grid may evolve with a continuation of the status quo

Cost-efficient microgrids and distributed generation will displace grid-supplied electricity for most consumers.

Customers will choose not to connect to the grid, because it will not offer them any "must-have" services or value. Customers will instead be willing to take a "do-it-yourself" mentality. Customers with appropriate knowledge and resources will tap into cost-effective home- and community-based generation and microgrid options, which they may self-manage or that may be provided, financed, and managed by a third-party service provider. Cost-effective distributed energy storage will enable high reliability. Subsidies currently encouraging renewable energy and distributed generation will no longer be needed.

Given current business models and rate structures, lower demand and a shrinking ratepayer base will lead the utility into a "death spiral" where costs cannot be sufficiently recovered to maintain the health of the grid. As more customers depart the grid, inequality will rise. The existing regulatory model is based on a socialization of rates that gives all users a similar experience (in terms of prices and reliability). In Vision A, however, customers that remain on the grid (high-risk, low-income) may bear the brunt of higher prices per user and poorer service and reliability.

New Capabilities and Functions

- **An ecosystem of aggregators and third-party owner/operators** of distributed resources (generation, microgrid backup systems, leasing options) that will serve customers, neighborhoods, or communities. A competitive marketplace will exist for distributed generation, and independent companies will provide services (e.g., leases and O&M contracts). These entities will provide the services of the current utility and enable customers to be fully off the grid.
- **A shifting of operational requirements, responsibilities, and penalties to the customer/end user.** Customers or their contracted agent will need to provide operational information to allow for the balancing and operation of the overall system. Operational requirements, responsibilities, and penalties will be passed down to the customer. For example, customers who receive compensation for participation in reliability-enhancing programs, such as selling

spinning reserve, will need to accept some level of responsibility if they do not meet their agreements.

Differences for the Operations Centers

Transmission and Distribution:

- **Generation will be supplied at the local level**, which reduces demand for centralized generation and use of the associated transmission infrastructure.
- **The distribution system will persist**, but in a greatly diminished capacity. With many customers self-supplying their electricity, the only groups that will remain on the distribution grid are the low-income, the sick, and business and industry.
- **The limited distribution system will meld with the transmission system.** Distribution will be linked, but there will not be any visibility between the two systems. Greater visibility into distribution operations will be needed.
- **Investments in the distribution system will be minimal, hampered by shrinking revenues and continued volumetric pricing.** To ensure there is some revenue for system maintenance, citizens may be required to pay a fee. Another possibility is that energy providers (gas companies, etc.) could be required to pay a tax, surcharge, or fee because they are taking on the role of electric service providers.

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

- **There is a need for policies and tools that enable an orderly transition to avoid a "death spiral."**
  - Reform is required to create a regulatory framework that supports an orderly transition to ensure that people who have less are not left behind.
  - Energy equality is a central question. The question of whether access to electricity/energy is a right needs to be answered. Inequality rises as more customers depart the grid. Only those with limited means (the sick, aged, and low-income) or a need for high reliability will remain, and they will pay higher rates because there will be fewer ratepayers to pay for grid infrastructure and maintenance costs.
  - To ensure service for the grid's remaining customers, it is necessary to consider ways to fund ongoing grid O&M. Taxes, surcharges, licensing fees, and other instruments may be necessary to counteract the shrinking ratepayer base. Utilities will experience interest rate increases, which will lead to a decreased availability of funds and make it more difficult for utilities to obtain the capital required for system investments.

Vision B:	***The next-generation grid***
	Grid evolution with new policy, investment, and regulatory support

The electricity delivery system will be enhanced to provide added services and value.

Customers will choose to remain connected to the grid, even if they self-generate some or all of their power. The grid will enable them to sell excess generation and buy optional grid-supplied backup electricity. A flourishing ecosystem of new tools and "apps" will provide customer-facing, actionable information that helps consumers manage their energy use and provides other, yet-to-be-defined services. Rate structures and regulatory frameworks will support ongoing operation of and investment in the grid.

New Capabilities and Functions

- **Digital mapping systems.** Active customer load system mapping and load flow models that identify the location, type, and activity of end-user/edge-of-grid devices and systems.
- **Links and interfaces between systems to support third-party service providers.** These providers will need to interface with utility customer management systems, distributed generation management systems, and customer-facing systems. To enable customers to take action and be paid for participation, these varied systems will need to link and communicate.
- **A standard, universally accepted data engine to enable intelligence for end-use devices** and their integration into the distribution system. This would be similar to the way that standard data engines have enabled the development of cell phone apps. Energy apps can be built on this standard engine, delivering new tools and abilities to consumers.
- **Standard, universally accepted data formats and methods for sharing data.** Standard data formats and data-sharing methods would offer an important foundation for enabling linking and communication between multiple systems.
- **Probabilistic/risk-based planning** to support risk-aware investment and regulation.
- **Mechanisms for community aggregation** that allow all customers to participate.
- **Multidirectional flow and local distribution balancing. More tools and flexibility for multimodal switching.**
- **Robust transactional capabilities** to support the buying and selling of excess generation from individual and community sources.
- **New customer rate structures that reflect and enable flexibility** and allow the buying and selling of excess generation. More flexible and dynamic rate structures could comprise a base fee (to support infrastructure maintenance and system development) and an additional energy use charge. New, market-driven pricing structures will be needed to allow for differentiated services. Utilities will need a new form of compensation for customers who generate. Pricing structures will also need to address the large investments that will be required to provide system-wide visibility, greater flexibility, and transactional capabilities, passing a share of those costs to ratepayers, if appropriate.
- **Dynamic pricing and market signals, as well as clear pricing and demand signals** that give customers actionable information. How the grid behaves will not be relevant to the customer—data and signals will need to be expressed in terms customers can understand and act on.

Differences for the Operations Centers:

Transmission:

- **There will be a melding of the transmission and distribution systems.** The two will become integrated, such that transmission operations reach further into the distribution system, and vice versa.
- **Closer integration of transmission and distribution operations.** The lines between the two may blur as the distribution system adds capabilities that are similar to transmission system capabilities. Operators will need to manage across both the transmission and distribution systems as well as communicate with other operators across both systems. One challenge to achieving the integration of transmission and distribution will be the networked nature of transmission; moving the distribution system to a networked model will require major investments and new infrastructure.
- **More visibility into the transmission system.** Transmission will need to be able to match a customer selling excess generation with a customer who needs to purchase it.

Distribution:

- **New tools and flexibility to handle the system's greater complexity**. The addition of many more devices and less-predictable loads and generation will increase complexity as well as the need for multidirectional flows and load balancing.
- **Enhanced visibility** into the distribution system, down to the end-user/device level.
- **Interactions and interfaces with third-party providers** and aggregators of generation, microgrids, storage, and backup.
- **Localized exchanges and commerce**, matching individual customers with individual generators.

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

- **Regulatory and rate reform are both required to encourage distribution system investment and development and to enable local services.**
  - Regulatory reform is required in many areas—to encourage and support balancing authority capabilities, to enable technical and infrastructure development, and to lay the groundwork for exchanges and commerce at a local level. Current permitting and regulatory processes burden those making initial capital investments in systems and infrastructure.
  - Rate reform is required. Social engineering is inherent in rates, providing similar prices and experiences for all customers who have chosen to opt into the system. If customers choose to leave the market, shrinking ratepayer revenue could lead to diminished roles for the grid and utilities, as well as reduced service for remaining customers. This could be counteracted by a decision that the grid is a public good that should be publicly funded in some way; for example, through a tax or fee. Additionally, there may be a need to define baseline reliability goals and an obligation to serve. Development and innovation may be hampered by current rate structures (such as net metering and volumetric pricing), which send distorted signals to the market. The current inflexibility in ratemaking does not enable pricing for differentiated services. Ultimately, new rate

and market structures will be needed that support exchanges and commerce at the local level (such as excess generation, reliability and ancillary services, and third-party services and financing).

Necessary Actions (for either Vision A or Vision B)

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Establish a task force or other similar process to look closely at the utility business model. The process should explore how utilities make money, how ratepayers are protected, and how social objectives are achieved. Cross-sector, multi-viewpoint thinking would significantly enhance the discussions.** Discuss with capital market participants the benefits and challenges of current investment models, including the barriers and factors that are hampering or motivating investments. System-level investments required for the grid to evolve are very large. If ratepayers are to shoulder these investments, there needs to be a compelling business case. The task force should also explore whether (and how) energy access should be ensured for vulnerable groups.
- **Develop/coalesce a vision for the enabling infrastructure.** Encourage and drive industry consensus on future terminology and standards that will enable the creation and integration of new services and tools.
- **Develop a strategy for workforce investment and workforce skills assessment.** This would be a starting point for a much broader effort to build capacity and develop the workforce to support the grid's new, value-added capabilities and functions.
- **Invest in developing new standards and technology to support the new grid.**

Scenario 3. Higher Local Reliability through Multi-Customer Microgrids

Description of the Scenario

This scenario is characterized by:

- Microgrids that are widely deployed to meet a variety of customer needs: increased reliability, greener generation, higher power quality, etc.
- Increased sophistication of these microgrids, with a mature market by 2020.
- Microgrids becoming a dominant force in grid operations in 2030 and beyond.
- Microgrid serving a single customer or multiple customers.
- Microgrids that utilize larger grid infrastructure but are also able to operate independently when necessary.
- A possible disruptive or destabilizing impact of microgrids on traditional grid (shrinking number of ratepayers to support grid infrastructure, rising costs per ratepayer).

Together, these characteristics suggest a need for:

- Appropriate grid interface standards to allow for optimal operation of the grid, the microgrid(s), and both together.
- Consideration for how these microgrids will impact infrastructure investment for the larger grid.

Path Forward: Articulating the Vision

The following summarizes the Scenario 3 breakout session discussions. This content was generated entirely by participants and reflects their vision for the future electricity grid under the Scenario 3 assumptions.

Description of Microgrid

Participants first noted that "microgrid" is a very broad concept, and then identified the following characteristics of the definition in order to guide discussion:

- Capability to balance, island.
- A portfolio network—power, energy, and network management.
- The ability to preemptively island from the grid seamlessly.
- Provides ancillary services—reactive power and voltage control.
- Automatic synchronization and restoration.

Description of the Group's Future Grid, Based on the Scenario

- **A large portfolio of microgrids.** Increased deployment of microgrids will occur due to decreased technology costs, the constant threat of departing central load from the grid, an event that illustrates grid vulnerability, and appreciation of microgrids' ability to generate their own power. Microgrids will be widespread and meet the requirements of customers with specific needs that are not met by the larger grid, such as cleaner generation, increased reliability, high power quality, etc. Portfolio managers will have to have decision power to manage and operate the microgrid and its interface, and customers will have to agree to this to the extent they participate.
- **Large-scale grid operations.** Well-behaved microgrids will be a component of the larger overall

grid. The larger grid will still be needed to serve as a backbone that can provide ancillary services such as voltage and reactive power regulation. The microgrid interactions will be handled through a market mechanism that allows operators to optimize power management. Distribution-network-related constraints will need to be accounted for.

- **Blurring of transmission and distribution (Federal Energy Regulatory Commission and states).** There will be real questions about the redundancy of capabilities and services between transmission system operators and local distribution operators, including who is more efficient. The system will need to be integrated to provide both situational awareness and knowledge about what devices were installed and where. Standard of conduct rules will need to change; utilities cannot talk candidly about this, and transmission and distribution entities will need to be able to discuss what works.
- **A competitive national microgrid market.** A competitive national market for microgrid deployment will evolve, with national entities that develop subdivisions and serve as the owner and developer. Regulation will be modified to allow this to occur. The technology will be accessible and high barriers to entry will not exist. Utilities might not exist in their current state, and it is not clear whether they will still have an advantage; however, a platform for large-scale grid operations will exist. Non-regulated microgrid entities will play a role. The market may consolidate into several national players—economies of scope and scale will not exist in every region. Some of these developers may want to be connected to the grid, and others may want to operate independently—these developers would utilize a bidding process. Energy development, in addition to generation, will be competitive.

New Capabilities and Functions

- **Smaller, more efficient, clean generation.** As technology evolves, microgrids will offer opportunities for greater efficiencies and orders of magnitude reductions in size. There will also be an opportunity to leverage microgrids to utilize cleaner generation sources. There is currently an U.S. Environmental Protection Agency effort to define microgrids as the vehicle of choice for greenhouse gas reduction.
- **Dynamic (intra and inter) microgrid integration.** Automatic synchronization and restoration will be needed. Standards will need to be in place so that distributed devices can be dynamically regulated.
- **Flexible distribution-level markets.** A microgrid services market will be developed. More high-tech equipment will be closer to customers at the edge. New cost/benefit methodologies will be needed to consider indirect costs.
- **Superior reliability, survivability, and resilience.** Microgrids offer the benefits of reliability, survivability, and resilience.

Differences for the Operations Centers

Transmission:

- **Redefining roles and responsibilities.**
- **Increased complexity and dependence on IT (applies to both transmission and distribution).** The expansion of microgrids will lead to greater reliance on IT. This will change the structure of the workforce because the complexity of the tools will exceed the current skill set of the workforce. In particular, it will be important to manage the complexity for smaller customers at the nanogrid level. There will also be a need for IT at the customer end.
- **Blurring of transmission and distribution and the end user.**
- **National, integrated, open-access grid model.**

- **Balancing over a wider region.** This will involve getting beyond the balancing authorities and coming up with wider situational awareness.

Distribution:

- **More emphasis on low-voltage (real-time) networks (models and a method for measurement).** Dynamically controllable two-way flows.
    - The ability to communicate the customers' expectations in real time would be a helpful forecasting tool, especially for large industrial customers. Currently there are predictive models on load and forecasting on every circuit; however, these tools will need to be enhanced (e.g., instead of just forecasting the presence of clouds, forecasting where the clouds will be).
    - Standards will need to be in place so that distributed devices can be dynamically regulated. At the federal level, steps will need to be taken so that major devices communicate with utilities. One idea is to offer incentives for retail devices if they have standardized interfaces that communicate with utilities.
- **More transparency and information for two-way flows/functional markets.** Currently, operators can communicate with microgrids, but failure to have massive two-way flows of information will be a real impediment for microgrids and distributed resources. However, this is not an insurmountable impediment. Situational awareness will be needed so that the system operator knows what devices are installed and where.

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

- **A business model that encourages appropriate investment in infrastructure.** A change is needed to the way utilities make money. A new investment and cost recovery model is needed to attract investment and recover costs, although it is unclear what the new model might look like. One possibility is moving from a model based on capital costs to one that is based on increased efficiencies or cost reductions. With a fixed cost infrastructure that is seeing a reduction in demand, utilities will be much more careful about capital projects (transmission investments are not "no risk" anymore), potentially reducing both capital and O&M expenditures. Utilities need reasonable expectations for a rate of return; otherwise, their ability to borrow at low rates will be limited. Uncertainties about risk and return limit investor interest; more certainty would attract investment. Options include government-backed returns on investment for the difference between the cost and the money collected from customers, and pre-approval investment mechanisms. There was discussion about whether low-cost access to capital markets by a government-regulated entity is good, or whether competition is a better idea.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Pursue rate design.** The current rate structure of charging by kilowatt-hour will not work with the future grid. The operator will need a means of getting a decent rate of return. One idea is to move from an electron delivery infrastructure to a services delivery infrastructure. Utilities could offer infrastructure that provides other services. Customers who opt-in to the microgrid could also be asked to pay a "reliability charge" in order to be connected to the grid. Customers with critical loads, who absolutely need power, will be more willing to pay for power than customers who do not have these constraints. Performance-based rate-making approaches that reward (1) utilities for encouraging innovation and (2) new metrics for determining customer value could help.

  - Another consideration will be to accommodate the desires and demands of customers. Traditional rate designs are built around customer classes (i.e., industrial, commercial, residential); however, to meet changing customer expectations and provide rate design choices, new pricing models are needed. Customers are not simply paying for electricity; they are also paying for comfort, safety, security, and productivity. The service component will be a bigger part of the future business model. Microgrid customers or customers with distributed generation know that they are contributing to the grid, but the current regulatory scheme does not have a way to reimburse them. Customers also want choice (although too many choices could lead to too much complexity, so simplicity is also valued) and have high expectations. Over the next 15 years, it will become even more evident that customers within the same class (e.g., residential) are different and will need and expect different services from the utilities.
  - The new rate design will need to include considerations for socializing low-income customers. Commissions are supporting the concept of electricity as a right; this issue needs to be resolved.

- **Standardize and integrate tools.** Standardization on interconnection and contracts is critical. Currently, soft costs (the time and money needed to add microgrid equipment without changing utility interconnect) can be prohibitive. Standardization of the software and hardware will help further adoption. Standards must be put into place so that distributed devices can be dynamically regulated. At the federal level, major devices need to be able to communicate with utilities. Perhaps the government could offer incentives for retail devices that have standardized interfaces that communicate with utilities.
- **Monetize multiple value streams**. It is important to determine how and with what method utilities can draw multiple value streams from their infrastructure. The cost to maintain the wire infrastructure is high and demand for using those wires is decreasing. Utilities will need to determine what their competitive value-added services are (e.g., uninterruptible power supply source, clean power from wind generators, and frequency regulation). There are national companies that already have the competencies, models, and customer bases to do this, but utilities have not done this previously and are hampered by current regulatory models.

Scenario 4: Transitioning Central Generation to Clean Energy Sources—Large Wind, Large Solar, and Large Gas

Description of the Scenario

This scenario is characterized by:

- Increasingly affordable natural gas; rising use of natural gas.
- Lower costs for wind, solar, and other renewable generation technologies (as a result of incentives and increasing market demand).
- A majority of new generating capacity being supplied by renewables.
- New policies and regulations that are driving up the price of coal, oil, and nuclear.
- New participants in the market; impacts of changing wholesale prices on the profit margins of traditional and renewable power generators.
- New operating characteristics for the generation fleet.
- Possible strain from ramping and cycling.

Together, these characteristics suggest a need for:

- Increased infrastructure to transmit electricity from sites where it is produced to where it is used.
- Increased flexibility of the power system to manage the variability and uncertainty of generation from intermittent renewables.
- Strategies for addressing increasing penetration of non-dispatchable resources; curtailment.
- New alternatives to traditional planning processes to avoid overbuilding some asset capacity and underbuilding others.

Path Forward: Articulating the Vision

The following summarizes the Scenario 4 breakout session discussions. This content was generated entirely by participants and reflects their vision for the future electricity grid under the Scenario 4 assumptions.

Description of the Group's Future Grid, Based on the Scenario

- **Controlling demand at the same level as supply.** Demand will need to be controlled similar to generation; only controlling generation will not work.
- **Storage will be a key asset at the generation site.** Storage capability at the generation site will provide more value to the distribution grid than the transmission grid. The storage location will need to be evaluated to determine the best location.
- **Potential stranded costs with generation retirement and lots of cost shifting.** Stranded costs due to siting new transmission, not-in-my-backyard (NIMBY) issues, and costs associated with who pays (e.g., the stranded cost associated with transmission lines when getting rid of a coal plant) are not currently taken into account. The possibility of a substantial amount of cost shifting occurring is a big concern for the future grid.
- **Regulatory policy will embrace long transmission, High Voltage Direct Current lines.** Regulatory policy will need to drive long direct current (DC) connects. Increased transmission capacity will be needed to reduce the congestion caused by wind, but investment capital is

currently unavailable to make anything happen. A significant amount of wind energy is currently available, but there is not enough capacity to transmit it to load centers. The system will need to be responsive to wide fluctuations and ramping, especially when wind falls off. This congestion will need to be priced.

- **Grid control will become more complex.** Complexity will also increase with shorter control cycles.

> **A participant shares an example of grid control becoming more complex**
>
> In the United States, our operating models are one-hour "look ahead" models. In other parts of the globe, five-minute "look ahead" models are used. On the customer side, smart meters are capable of providing near-real-time interval data; however, most U.S. utilities that have smart meters deployed are only collecting the data on a 15-minute or one-hour interval. If the transmission operators and generators are limited in their ability to contract for generation based on an hourly model, generators bidding into the market may be seeing congestion pricing and transmission access limits that do not truly exist. The technology to make this more real time exists, but the complexity of managing the information, the market contracts, and the operations is the limiting factor.

<u>New Capabilities and Functions</u>

- **Value-based services paradigm (with pricing transparency).** Utilities will become energy service providers; their business model will focus on offering a combination of services instead of on volumetric sales. These services will include distributed generation, energy efficiency, and behavioral/consumer engagement. An aggregator will emerge who will provide control and back office services, such as settlements and forecasting, as well as track wind. Merchant transmission will also emerge. There will also be more pricing transparency. It will be important to have the right pricing signals to get the right generation, transmission, distribution, and market products. Pricing models should account for dispatch—accounting for those that follow the dispatch and those that do not. Added flexibility will encourage these different types of generation to compete on a competitive basis. A set of pricing criteria should be established; owners/operators could be paid more or less depending on how many criteria are met.

<u>Differences for the Operations Centers</u>

Transmission and Distribution:

- **Greater system awareness, decision making, automatic controls, and forecasting of variable generation that enable ramp products in the market.** The ability to forecast wind and solar accurately will be needed so that ramp products can be reserved in the market. The ramping ability will be the product; if it goes down faster, the capacity needs to go up. System awareness will require visibility from the end user through to the generation source.
- **Standards will be needed for different devices that allow for interoperability, vendor-neutral solutions.** There will need to be a standard way of communicating with demand response, inverters, and energy storage, as well as a standard way to plug them into the system—similar to a USB connection. Both vendors and utilities will need to be involved in the standards discussions so that open communication protocols can be established for the new asset classes under development. This will allow energy management systems to communicate with one another and will aid operations.

- **Common pricing protocols and market structures (to enable major long distance transfers).** Common market rules will be needed; non-standardized structures make operations very difficult. A common nationwide (East and West) business model and a common market focused on reliability will be needed. Without visibility across regions, utilities can be overextended in one region without another region recognizing the problem.
- **More balancing authorities, with more autonomy; each plant will be its own balancing authority, decoupling reliability from balancing authority.** In a federation of microgrids, everyone—producers and consumers—has responsibilities. Balancing authorities must have increased granularity. The reliability coordinator's responsibilities will change—the balancing authority will be separated from the reliability coordinator, leading to a need for fewer coordinators.
- **More participants and new participants means complexity will go up.** There will be more small players and non-utility stakeholders who have different expectations and mentalities. These players will have to be managed differently because they have less of an understanding of the grid's overall operations and functions, and they do not have an "obligation-to-serve" culture similar to utilities. Introducing more types of participants also introduces more sources of failure potential. More coordination and engagement will be needed to bring diverse stakeholders together. More forums for coordination will also be needed.
- **More automation, more predictive capacity, and more engineering support in the control room.** Control room operators will have a new class of assets to address at scale. Cooperation and information sharing has to become easier; it will become more automated and feature less human intervention. There will still be dispatchers, but their role will change, facilitated by situational awareness. Engineers may become dispatchers and have to make decisions based on data and recommendations provided by a system—this will represent engineering support moving into the control room. Engineers will have responsibilities 24/7, which is a very clear role change. Conventional operators act on instinct based on their experience; with more engineering, their decisions will need to be more data driven.
- **Operations at all levels that will be more engineering and economically oriented.** There will be a cost consequence to everything.

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

- **Balance the "common good" and "beneficiary pays" philosophies of regulation.** Issues related to the concept of common good/obligation to serve need to be addressed. The lack of deregulation down to the retail customer is a barrier.
- **Policy should address environmental externalities cost effectively.** The cost of meeting environmental regulations is more expensive than the societal benefit provided by meeting those regulations.
- **Energy regulation involves numerous government entities. Coordination is greatly needed so processes and approvals can be streamlined.** Too many agencies at all levels are involved. Other countries have fewer agencies involved, and operations are smoother and quicker. The lack of coordination between agencies is a substantial barrier to the development of an economically viable grid, and better coordination will be required in the future because state lines will need to be crossed.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Improve coordination among regulatory agencies.** Better coordination is needed among regulatory agencies (state and federal) in order to streamline and speed up processes and approvals.
- **Offer transparent pricing for all services that form a part of the resilient grid.** Customers must be informed about the services utilities are providing beyond remnants of power. Customers need to understand what services they are getting and what each service costs. There will need to be price and cost allocation, but there will also need to be a common price scheme for all variable services, such as energy services, ramping services, ancillary services, voltage and reactive power services, and emergency services. There may be a basic O&M charge for residential customers, perhaps in the model of a base rate and a usage surcharge. Consumers will pay more for reliability; they will need to understand that reliability is more expensive for more remote customers.
- **Enable new transmission.** Currently, a lot of new transmission lines may not be fully utilized (could have more efficient usage) and are not priced correctly. The fidelity of transmission assets' costs and benefits needs to be improved.
- **Enhance grid flexibility.** The system needs to be responsive to wide fluctuations and ramping, especially the fall off.

Scenario 5: Planning for Empowered Customers

Description of the Scenario

This scenario is characterized by:

- Technological innovations, new market structures, changing customer expectations, and policies that foster customer empowerment.
- Customers being more informed about their options, in part due to social media.
- Rising electricity prices and falling distributed generation costs, which lead customers to more closely consider their options.
- Increased interest in energy efficiency.
- Customer behavior changes as a result of education that will result in lower electricity demand.

Together, these characteristics suggest a need for:

- Recognition that customers now have choices for meeting their specific electric power needs.
- A better understanding of customers' needs, desires, and choices.
- A better understanding of how increasing customer expectations and choices impact the distribution grid and the transmission grid.
- Consideration that by 2030, customers will have a profound impact on how the energy value chain is built and operated.

Path Forward: Articulating the Vision

The following summarizes the Scenario 5 breakout session discussions. This content was generated entirely by participants and reflects their vision for the future electricity grid under the Scenario 5 assumptions.

Description of the Group's Future Grid, Based on the Scenario

- **Accommodate/leverage distributed prosumers.** The number of distributed prosumers is growing. The grid will have to determine how it will relate to them as well as educate them about their role in relation to the grid. Prosumers will need to understand the value of grid services (e.g., provider of last resort, power quality) in order to be willing to pay for these services.
- **Clean, flexible, and resilient.** Given public policy, public opinion, and the current status of the resource mix, it is reasonable to expect that the resource mix for the future grid will be cleaner, as well as more distributed. With renewable portfolio standards (RPSs), there is an expectation of cleaner generation sources. Given that the majority of the states in the Pacific Northwest are on track to meet or beat their RPS targets, it is reasonable to expect that these standards will be raised. The grid will need to be robust enough to accommodate a variety of generation: wind microgeneration, distributed generation, etc.

New Capabilities and Functions

- **Accommodate the full spectrum of customer demands from basic to high expectations.** Customers want choice. Customers cover a wide spectrum with a variety of motivating factors; for some, price is not the only motivation. Some might want the freedom to run their appliances whenever they want, even when provided with data that shows the optimal time. Others are motivated by environmental factors, preference for a certain bundle, or simplicity. Utilities will need to provide customers with choices to meet their different expectations and motivations. Utilities will need to provide accommodations for all customers, from those who want full automation to those who want to be actively involved. The demanding, high-expectation customer will want choice, cruise control, customization, privacy, and security. These customers might expect rates to decrease, or they might be willing to pay more for a higher-value service. Higher-income customers will be able to afford to fully engage in the new system, but other classes of customers—including some residential and small business customers—will not be able to take advantage. Utilities will need to consider the customers who rely on the affordability and reliability of their energy. Policy or regulation that allows for cost recovery will determine what choices customers have.
- **Two-way communication.** The move to two-way communications will require a lot of capital expenditures. It has yet to be determined if this cost can be socialized across the spectrum of customers or how these costs will be recovered. There are also the questions of how standards will change for devices that will be connected to a smart grid, and how standards will be built. New devices might come with a chip that will automatically communicate with the system—meeting a standard adopted by the nation or region—but there is still the issue of what to do with older equipment.
- **Automation at every level.** Devices at the residential level will be enabled so they automatically communicate with the system. Standards will need to be developed so these devices can "plug and play." Consideration needs to be given to the transition from older equipment to devices with new capabilities.
- **Transactive settlement.** Price signals will need to be present that allow consumers to react and change their energy usage patterns, and customers will have to be willing to sign up for these services. These settlements must be automated.
- **Data-driven analytics.**

Market Transformation in the Northwest

Market transformation and adoption can be enhanced through targeted programs. The Northwest has experienced this through the efforts of the Northwest Energy Alliance, which has helped convince consumers to conserve energy and switch to energy efficiency practices. The Northwest Energy Alliance's efforts are genuinely changing the market in the Northwest.

Differences for the Operations Centers

Transmission:

- **Blurring of the lines between transmission and distribution.**

Distribution:

- **Network and device management.**
- **Integration of planning, operations, and design.**
- **Visibility/verification.**

Message to Policy Makers

Participants determined that the following technical limitation(s) or operational constraint(s) should be considered by policy makers when developing future policies so electricity delivery is not adversely impacted:

Ensure financial viability of the grid in order to:

- **Maintain resiliency and reliability.** Americans expect a certain level of reliability and resiliency, and the future grid must meet those expectations at what are perceived to be reasonable rates. In addition, because consumers are becoming more tech-savvy, they are going to have higher expectations for resiliency and may turn to distributed sources to meet their resiliency needs if the grid does not accommodate them.
- **Integrate distributed energy resources.** Currently there is growth in distributed energy resources; customers will continue to expect to be able to install distributed energy resources such as solar panels. Leased rooftop solar will also be a factor—more people are now leasing rooftop solar panels than buying them. Aggregators may emerge, potentially on a residential level, but more likely in the microgrid fashion (e.g., for an office park, neighborhood, or new development), in which the group presents a single face to the utility.
- **Meet the changing needs of customers.** Customers' expectations and needs are changing. Energy providers must be able to meet these changing needs. In addition, young people are far more comfortable with technology, so their motivation and understanding will be different from past customers. This will impact the role that technology plays in the future grid.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Transition from volumetric- to fee-based pricing.** The move away from volumetric pricing will encourage consumers to value the utility's role, and they will be willing to pay fair prices for the services offered. Utilities need to consider what services are valuable to the consumer and what consumers will pay for. The revenue model must support these services rather than count on volumetric sales. It will be a challenge to incrementally address some of the opportunities with the transition without undoing a long history of public policy regarding cost allocation. It will also be hard to allow for a rate increase to pay for new infrastructure that will permit change that cannot even be imagined at this point; people want to build for the future, but it is hard to charge customers today for unquantifiable future benefits. When moving to a fee-based structure, it will be important to consider the possibility of future net-positive homes. This raises the question of what pricing structures will be applicable if every new home puts more supply into the market and there is no new demand.
- **Expand the scope of "least cost" principle to include total cost and externalities.**
- **Provide additional services to customers and effectively engage them.** The grid will still have a role as the provider of last resort, a way to sell excess power, and a means of bringing in large-scale solar power and hydropower; the changes needed for the grid to fill this role need to be identified. However, the grid must also provide additional services that people value and thus spend more for. The grid value will also have to appeal to aggregators that negotiate on behalf of a group of customers.

Additional Discussions

In addition to the topics on which the Scenario 5 group was asked to report, participants discussed a number of other topics related to the future of the grid:

1. Customer in 2030	**2. Who/what are interfaces with future grid**	**3. What new requirements does the grid have for input from consumers?**
Participants predicted characteristics of customers in 2030. • Full spectrum of consumers • Universal access – reliable • High expectation: demand choice ○ Cruise control/ customization • Constantly evolving/gets better • Resiliency • Microgrids/aggregations • Cleaner/sustainable sourcing • Prosumers • Storage (*not unanimous among participants*) • Lower demand *(not unanimous among participants)*	*Participants identified what entities will interface with the future grid.* • Customers • Communities • Service and product providers • Generation providers • Market operators • Balancing authorities • Transmission and distribution • Reliability coordinators • Compliance side	*Participants discussed the new requirements of the grid in terms of input from consumers.* • Data and analytics • Visibility/verification • Transactive • Standards • Control systems strategy • Consumer action or response • Dynamism and control over resources • Trust • Cost recovery

4. How will transmission and distribution interactions and relationships change?	**5. What technical capabilities will be needed that do not exist today?**	**6. Financial considerations of new grid—what market structures may be necessary (commodity vs. services model?)**
Participants discussed predicted changes in transmission and distribution interactions and relationships. • Integration of planning, operations, and design • Transactive • Standards • Awareness of transmission and distribution • Safety • Blurring of lines between transmission and distribution • Distributed intelligence and decision making at the edge	*Participants identified what new technical capabilities will be needed.* • Two-way communication and control • Automation • Transactive settlement • Energy management at customer level • User interface • Network and device management • Market interface • Load forecasting and modeling • Security	*Participants discussed the elements of determining the necessary market structures.* • Who pays and how • Transition from volumetric charge to grid connection charge • Ability to align cost and charges • New model for product and service revenue • Stranded costs • Speed of depreciation/speed of recovery • Minimizing cost shifts ○ Transparent cost shifts

7. How are grid operators/owners going to make money? What will be the new investment and funding requirements?	**8. What are the policy and regulatory barriers and what do we have to do to overcome them?**
Participants discussed the options for how grid operators/owners can generate income. • Approved integrated resource play • Interconnection fee plus a la carte (less than cost of storage) • On-bill financing • Return on equity on distributed devices • Incentive for energy efficiency or other performance-based result	*Participants discussed policy and regulatory barriers, as well as steps to overcome these barriers.* • "Least cost" principle • Consider total cost • Externalities • Broaden powers of commissions • Aligning state, regional, and federal regulatory oversight • Aligning state, regional, and federal legislative and administrative interaction • Alignment between asset list and tax life • Tax incentives • Public purpose charge • Eliminate rules to new financing mechanisms • Expand regulated utilities' ability to enable additional services • Regulatory lag • Actualization of authorized rate of return • Value of innovation—how viewed by regulators

Conclusion and Next Steps

The Western Region workshop provided an interactive forum for participants to identify a vision of the future grid based on their given scenario from a Western-Region perspective. Stakeholders participated in productive discussions, and the output from this workshop represents an excellent first step in gathering viewpoints from stakeholders nationwide. Feedback from participants regarding the workshop discussions was highly positive; participants particularly appreciated the open, frank discussions.

Output from this workshop, as well as from the subsequent regional workshops and the Executive Summit in Washington, DC, will feed into a final report, which will be published after the Executive Summit.

Appendix A. Setting the Stage: Factors to Consider

In order to frame the workshop discussions, participants received pre-read materials describing the scenarios and highlighting a number of key factors to consider that are shaping the electrical grid today and will likely emerge as dominant forces by 2030:

The shift to renewable generation. Rapid growth in wind capacity will continue, boosted by lower-cost, larger-sized turbines; larger production volumes; tax credits; consumer interest; and improved capacity factors. Solar photovoltaics (PVs) will also grow rapidly, driven by higher demand, consumer interest, lower PV module costs, and support from tax credits and other incentives. Although both wind and solar represent a small portion of the total electricity market, in regions where these resources are abundant, they can be disruptive and pose challenges to the grid. Biopower, geothermal, and hydropower will also grow rapidly. Some coal-fired plants may be retired.

The rise of cheap natural gas. Low natural gas prices and tightened emissions requirements will create more demand for natural gas from the power sector. Natural gas generation will grow through 2050, as low costs make existing natural gas plants more competitive with coal, and lower capital costs make natural-gas-fired plants a viable choice for new generation capacity.

Growing building energy efficiency. Growing federal adoption of Leadership in Energy & Environmental Design (LEED) standards for new building construction and state programs such as California's Zero Net Energy Building initiative will drive a broader growth of high-efficiency residential, commercial, and industrial building efforts that also feature on-site renewable energy generation or the purchase of renewable energy from utilities. The renewable requirements and possibility of on-site generation will greatly affect the performance of the grid, both locally and holistically, with implications for grid operation and stability.

The maturing of demand response. There will be increased availability of demand-side management to reduce peak demands, which in turn may help defer new generating capacity or improve operator flexibility in day-ahead or real-time operations. Dynamic pricing, time-of-use pricing, incentive payments, and other strategies will encourage users to change their energy consumption patterns. State policies and federal technical assistance, research, and development, will help drive adoption of demand response.

The smart grid. In response to aging infrastructure and a desire to increase electricity transmission and distribution efficiency, there will be an increased push for technology that utilizes remote controls and automation to better monitor and operate the grid. Increasingly over the past decade, Congress has taken a serious interest in electrical grid issues by passing various laws to address them. Title XIII of the 2007 Energy Independence and Security Act includes language specific to the smart grid. Congress continues to consider new legislation to address cyber security concerns, privacy and data access for consumers, and other policies to accelerate investments in the future grid.

Growth in energy storage. Maturing energy storage technologies will provide flexible solutions throughout the electricity value chain, helping grid operators address energy management, the intermittency of renewable power sources, and power quality issues.

Increase in microgrids. North America is the leading microgrid market in 2013, and it will remain so in the future, with major growth expected in the United States and worldwide. With the U.S. Department of Defense as an early adopter, and public investment in microgrids from a variety of other state, federal, and university entities, microgrid integration will be a crucial element in addressing grid reliability and resilience issues associated with energy generation from distributed renewables, power outages from natural disasters, and the increasing impacts to national security.

Smart cities and smart appliances. The amount of data being created and collected by municipalities and utilities is growing rapidly; by some estimates, it is expected to double every two years until 2020. Understanding and leveraging this data will be critical for municipalities. To maximize participation in smart cities, stakeholders will need to plan grid development in conjunction with planning authorities. Residential "smart appliances" are expected to become increasingly mainstream in 2015 and could reach up to $35 million in sales by 2020.

The rise of electric vehicles (EVs). EV sales account for less than 1% of total new light-duty vehicle sales, but federal support, state support, purchasing incentives, and fueling costs are aimed at boosting their adoption. The ways in which charging will impact the grid remain to be seen. The U.S. Department of Energy is encouraging more workplace charging. Technology advances could make quick chargers, wireless charging, or other methods more common at home. Utilities will need to evaluate their distribution system against these possible demand scenarios.

Overall growth in energy demand, with higher industrial demand and lower residential demand. Overall energy use is expected to increase by 2040. The U.S. Energy Information Administration (EIA) projects industrial-sector energy use to grow by 5.1 quadrillion British thermal units by 2040, primarily due to the increased use of low-priced natural gas and an increase in industrial shipments. However, EIA projects average electricity demand per household to decline by 6% by 2040.

A rising frequency of extreme weather events. Weather-related issues are the cause of nearly half of U.S. outages and are on the rise, meaning that grid resiliency will need to be addressed. In light of Superstorm Sandy, local leaders are considering options for local generation to address the most critical loads. Investments are being made in distributed power systems.

Policy and regulation. The grid will need to accommodate, forecast, and communicate with renewable generation resources spurred by renewable portfolio standards. The continuation of existing demand response policies would lead to a 4% reduction in U.S. peak demand by 2019. Renewable requirements for buildings and the possibility of on-site generation greatly affect the performance characteristics of the grid. Some states have launched emissions goals and cap-and-trade programs that may affect electric power producers and industry and shift production toward renewables.

Aging infrastructure and limited addition of new transmission capacity. Much of the U.S. power infrastructure is outdated and needs to be refurbished, replaced, or upgraded. Updating the existing infrastructure will present many challenges. These updates will become more and more necessary as the age of the infrastructure begins to show. Utilizing smart grid technology will increase grid resilience, efficiency, and reliability. The federal government has allocated billions of dollars to replace, expand, and refine grid infrastructure.

Appendix B. Workshop Agenda

GRIDWISE ALLIANCE

THE FUTURE OF THE GRID
Evolving to Meet America's Needs

Wednesday, December 11, 2013 • 8:30 am – 4:00 pm
Alstom Grid
10865 Willows Rd NE, Redmond, WA 98052

8:30 am **Welcome**
***Becky Harrison**, CEO, GridWise Alliance*
***Eric Lightner**, Director, Federal Smart Grid Task Force, US Department of Energy Office of Electricity Delivery and Energy Reliability*

8:40 am **Welcome from Host**
***Michael Atkinson**, President & CEO, Alstom Grid North America*

8:45 am **Opening Remarks**
***Hon. Philip Jones**, Commissioner, Washington Utilities and Transportation Commission*

9:05 am **Stage Setting: External Factors and Variables Impacting Future Electricity Delivery**
***Kevin Dasso**, Senior Director, Smart Grid and Technology Integration, Pacific Gas & Electric*

9:20 am **Visioning Exercise: A Future Grid – Capabilities and Functions**
Facilitated discussion with the entire group

If you were starting with a "blank sheet of paper" and did not have any constraints that are imposed by the legacy infrastructure and business models:
- How would you define the future role of the grid?
- What would the future grid look like?
- What capabilities and functions would be necessary to meet society's needs?
- What does grid operations look like?

9:50 am **Break**

10:05 am **Breakout Sessions**
Participants will be assigned to one of the following breakout sessions. A description of the scenarios will be provided in the pre-read materials. Breakout group assignments will be given to participants during registration.

1

Scenarios

- Balancing Supply and Demand as Grid Complexity Grows
- Involving Customers and Their Loads in Grid Operations
- Higher Local Reliability through Multi-customer Microgrids
- Transitioning Central Generation to Clean Energy Sources—Big Wind, Big Solar and Big Gas
- Planning for Empowered Customers

10:05 am **Breakout Group Discussion: *Defining Grid Operations***

For both the transmission and distribution system:

- What/who are the inputs/interfaces for the future grid?
- What new expectations do the players have for transmission grid and operations?
- What new requirements does the grid operator and grid have for the inputs (e.g., customers, third parties, etc.)?
- How will the T&D interactions and relationships change?
- What are the technical capabilities that will be needed that don't exist today?

12:05 pm **Lunch**

12:45 pm **Breakout Group Discussion: Business Models and Investments**

- What are the financial implications of the new grid? What market structure changes will be necessary? What market structure will be optimal for a commodity versus services model?
- How will grid owners/operators make money (rate based versus performance based)?
- What will be the new investment and funding requirements? How will both capital and O&M costs be covered?

Breakout Group Discussion: Barriers and Opportunities

- What are the policy and regulatory barriers at the Federal and State levels?
- How can these overcome?

2:20 **The Path Forward: Articulating Your Vision**

Breakout groups will be asked to describe their Grid of the Future, which is based on the vision discussed at the beginning of the day and the scenario given to the group, and provide answers to the following questions:

- What capabilities or functionality will the grid need to have?
- How will the operations center function?

2

- What is the one technical limitation or operational constraint that a policy maker would need to know when developing future policies so as not to adversely impact electricity delivery?
- What three actions must be undertaken in order to evolve to your cost effective, reliable, and resilient grid of the future?

3:00 pm **Report Outs**

3:45 pm **Summary and Next Steps**

4:00 pm **Adjourn**

Appendix C. Attendees

SA Anders
CUB Policy Center

Jesse Berst
Smart Cities Council

MaryLee Blackwood
Energetics Incorporated

Tanya Burns
Energetics Incorporated

Larry Buttress
Bonneville Power Administration

Phil Carver
Oregon Department of Energy – State of Oregon

Sunil Cherian
SPIRAE

Lee Coogan
GridWise Alliance

David Danner
Washington Utilities and Transportation Commission

Kevin Dasso
Pacific Gas and Electric Company

Paul De Martini
Newport Consulting

Erik Ellis
Arizona Public Service

Laura Feinstein
Puget Sound Energy

James Gallagher
New York State Smart Grid Consortium

Sibyl Geiselman
Eugene Water and Electric Board

Erik Gilbert
Navigant Consulting, Inc.

Jeff Goltz
Washington Utilities and Transportation Commission

John Hammerly
The Glarus Group

Becky Harrison
GridWise Alliance

Steve Hauser
New West Technologies

Josh Jacobs
Puget Sound Energy

Avnaesh Jayantilal
Alstom Grid

Philip Jones
Washington Utilities and Transportation Commission

Landis Kannberg
Pacific Northwest National Laboratory

Jeff Kensok
Puget Sound Energy

Mary Kimball
Attorney General of Washington

Peter Klauer
California Independent System Operator

Lee Krevat
San Diego Gas and Electric

Jayant Kumar
Alstom Grid

Eric Lightner
U.S. Department of Energy

Daniel Malarkey
1 Energy Systems

Bryan Nicholson
GridWise Alliance

Mark Oens
Snohomish County Public Utility District

Terry Oliver
Bonneville Power Administration

Miguel Ortega-Vazquez
University of Washington

Subhash Paluru
Western Area Power Administration

Julie Perez
New West Technologies

Michel Pesin
Seattle City Light

Dan Pfeiffer
Itron

Robin Podmore
IncSys

C. Valerie Riedel
Energetics Incorporated

Dave Roberts
OSIsoft

Alan Rose
Intel Corporation

Aleka Scott
PNGC Power

Justin Segall
Simple Energy

Richard Shaheen
Bonneville Power Administration

Gary Stuebing
Cisco Systems

Jim Taylor
Tucson Electric Power

Wade Troxell
College of Engineering, Colorado State University

Tony Usibelli
Washington State Department of Commerce – Energy Office

Mani Vadari
Modern Grid Solutions

Charles Vartanian
UniEnergy Technologies

Donald Von Dollen
Electric Power Research Institute

Byron Washom
University of California, San Diego

Dylan Waugh
Energetics Incorporated

Mark Zeller
Schweitzer Engineering Laboratories

LI ZHOU
California Independent System Operator